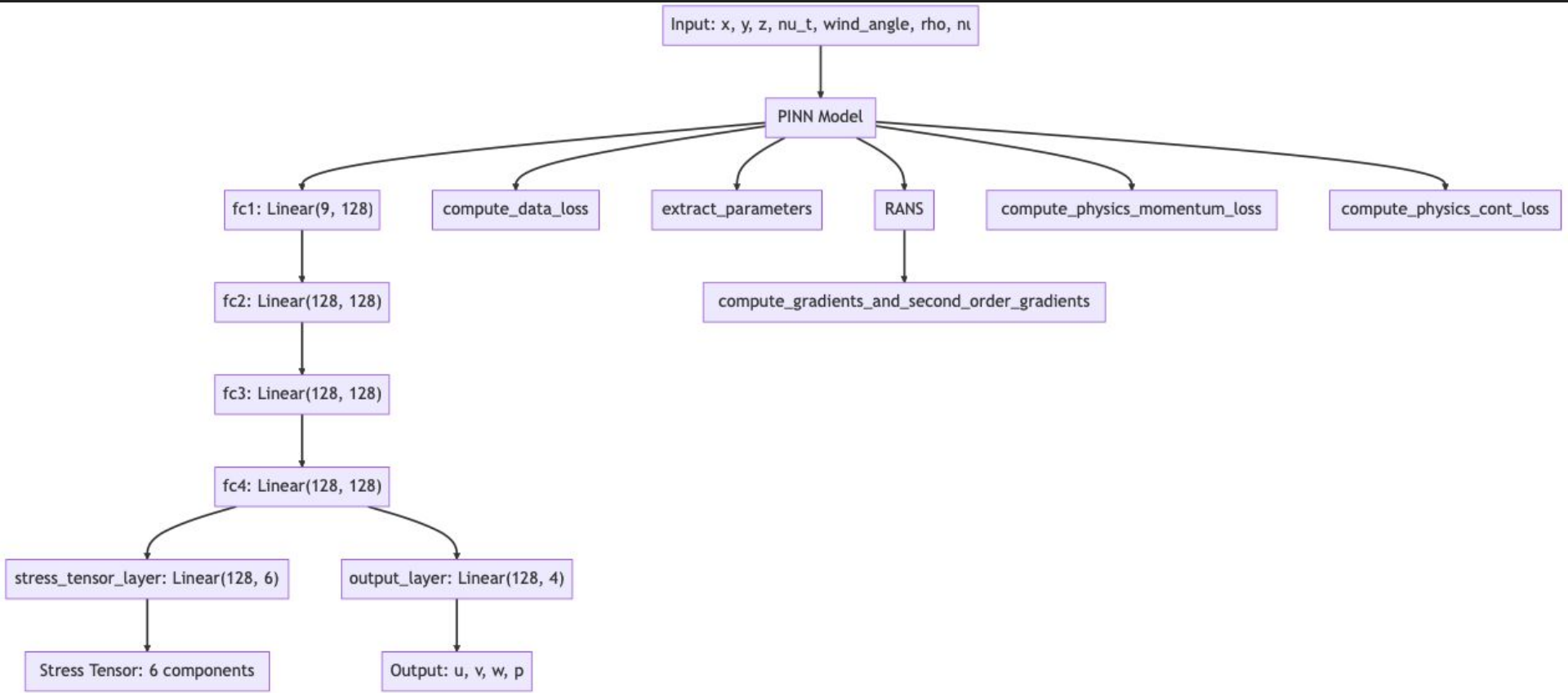
Update on PINNs

Application to Urban Wind Field Dispersion Studies

Neural Network Architecture



Some Parameters

Infinite epochs - instead the criteria for stopping is loss_{n} - loss_{n-1} < ε for 10 consecutive epochs where n is the epoch number and ε = 1E-5 (user defined)

We have the data for 7 angles, [0, 30, 60, 90, 120, 150, 180] in degrees

We concatenate the data for angles = [0, 30, 60, 120, 150, 180] and then take 80% of the dataset with random seed = 42 for training and 20% for testing

By using the whole dataset we hope to make the NN learn about wind angle such that the parameters become functions of the wind angle

We also would like the stress tensor to be learnt so that we do not have to assume models involving turbulence (ie. model free approach)

Then using the trained neural network we predict the data for angle = 90

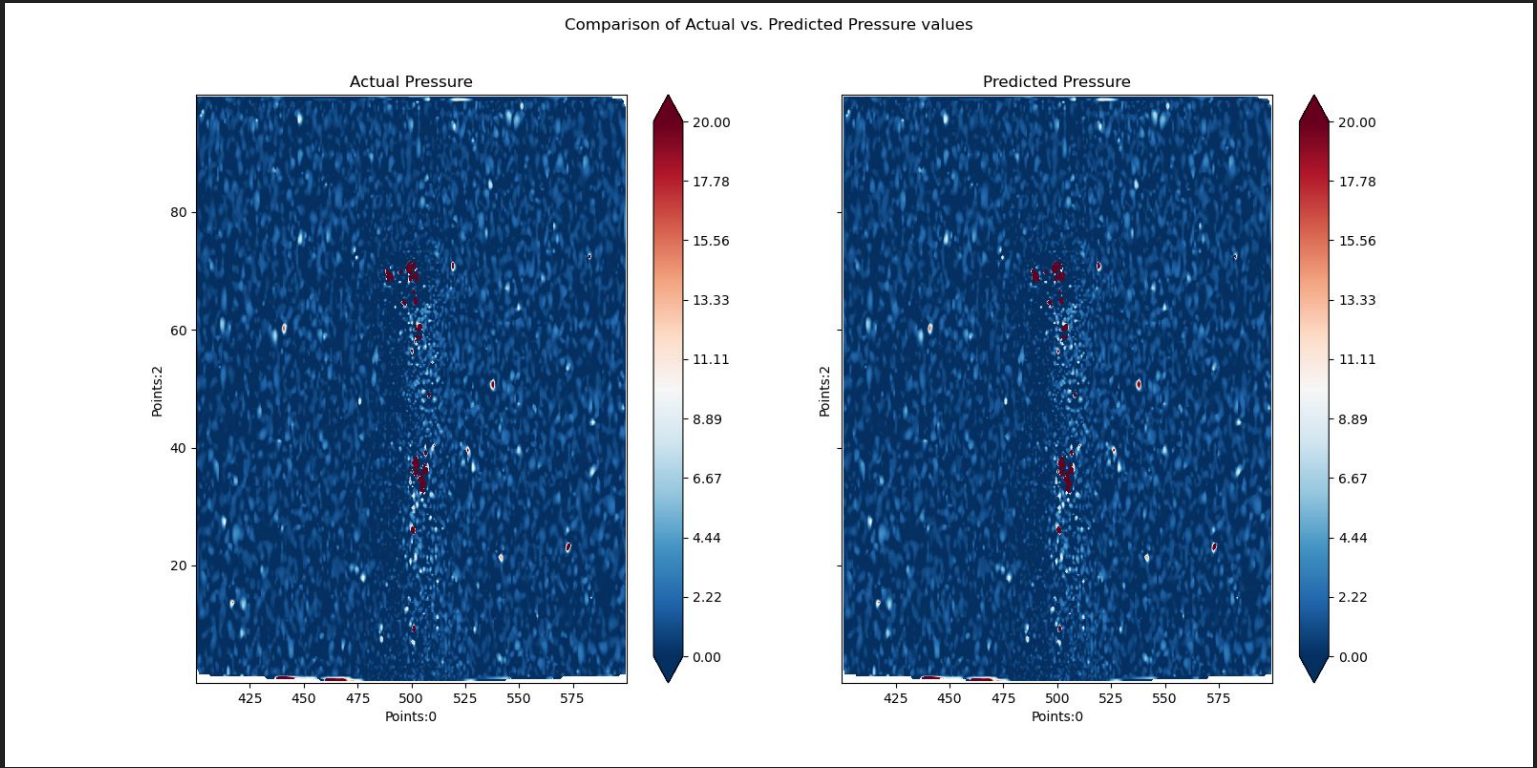
Progress so far - Data Loss Only (Adam Optimizer)

- Testing results are good
- Predicting results are not great

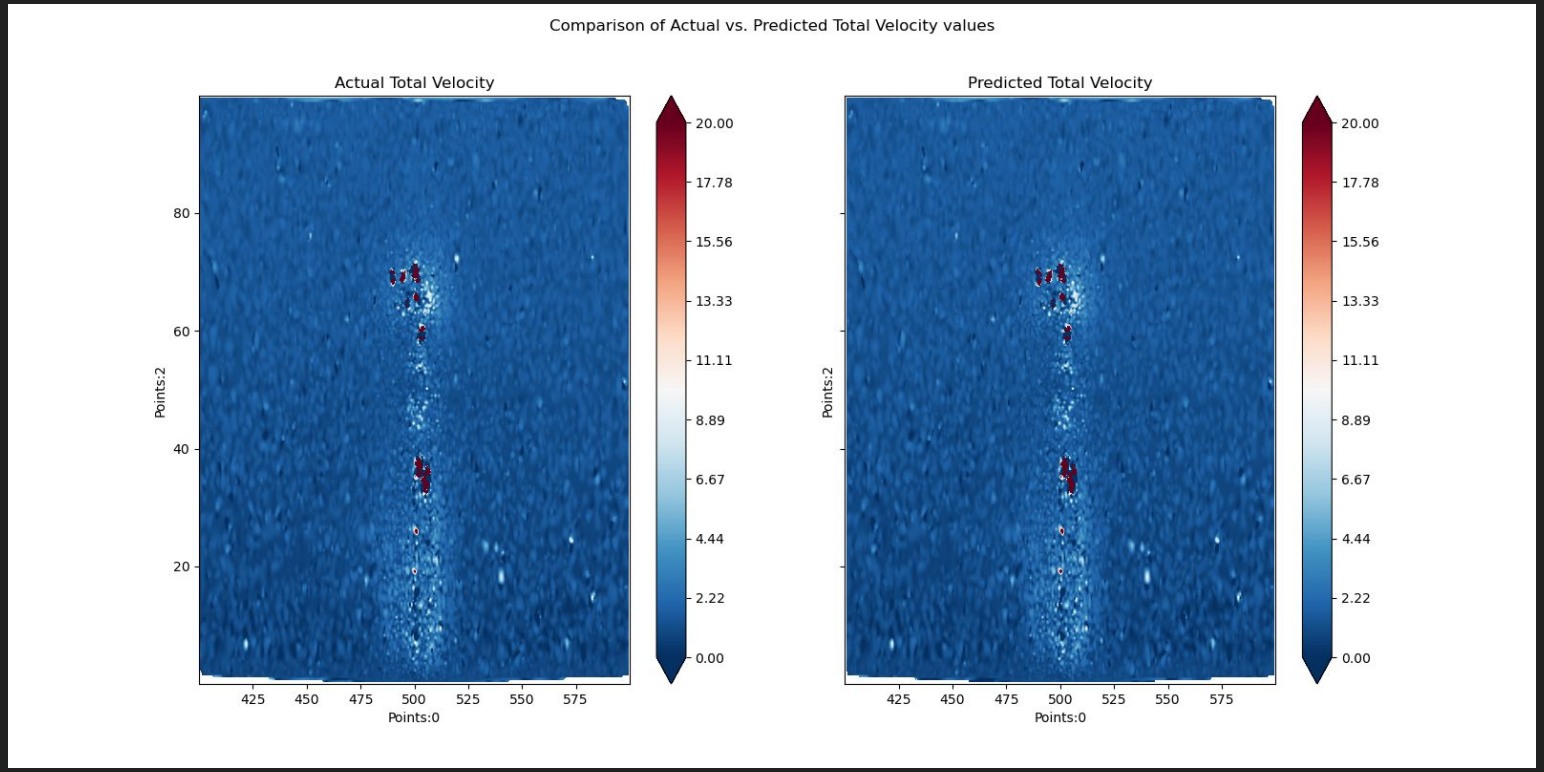
Progress so far - Data Loss Only (Adam Optimizer) - Testing Results - Metrics

Variable	MSE	RMSE	MAE	R2
Pressure	0.0011776087	0.034316305	0.020423971	0.998823731
Velocity:0	0.0013828328	0.03718646	0.021234445	0.9986191703
Velocity:1	0.0007224323	0.0268781	0.016232971	0.9992781438
Velocity:2	0.0052816323	0.07267484	0.039270695	0.9947135709

Progress so far - Data Loss Only (Adam Optimizer) - Testing Results - X-Z Pressure Plot



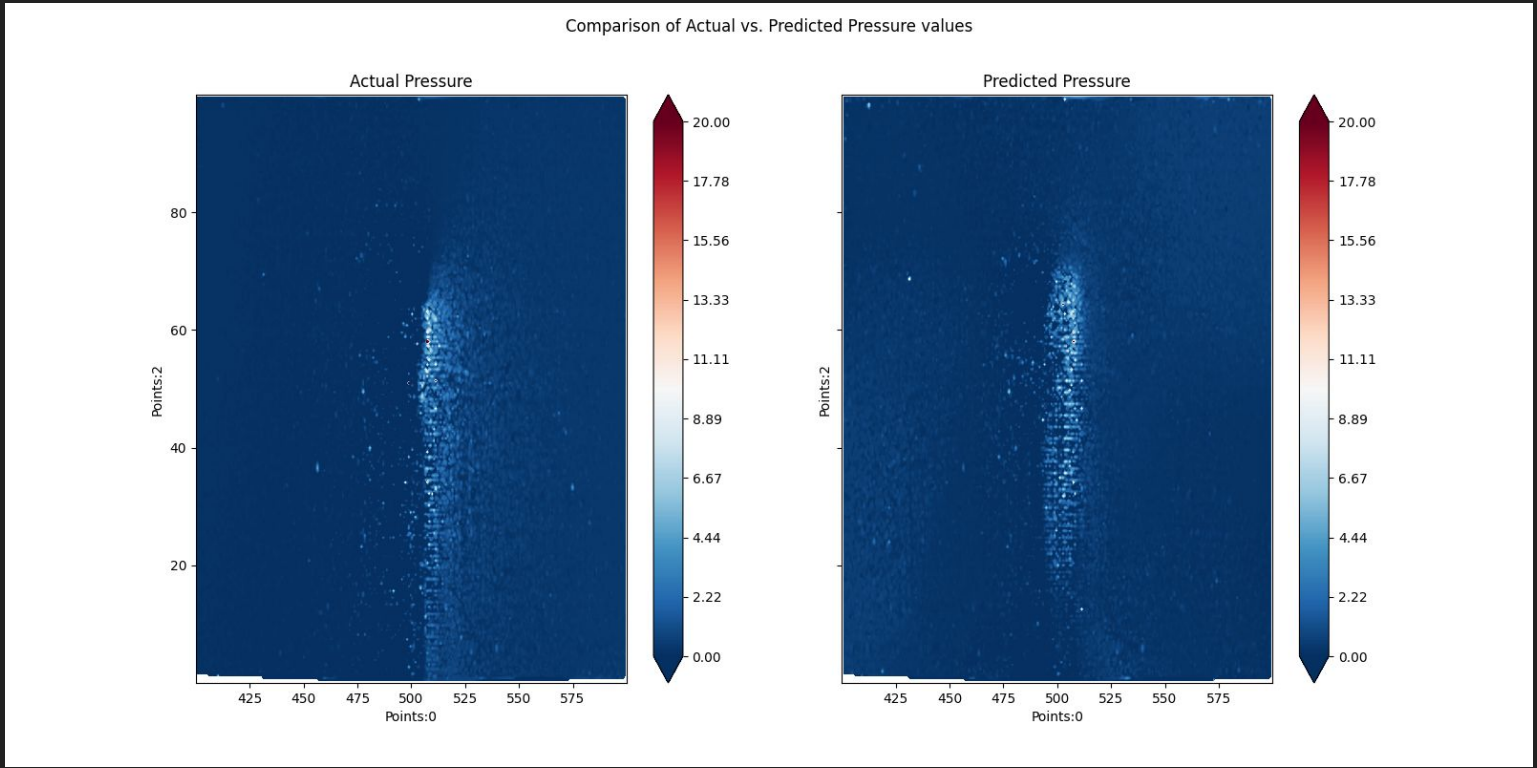
Progress so far - Data Loss Only (Adam Optimizer) - Testing Results - X-Z Total Velocity Plot



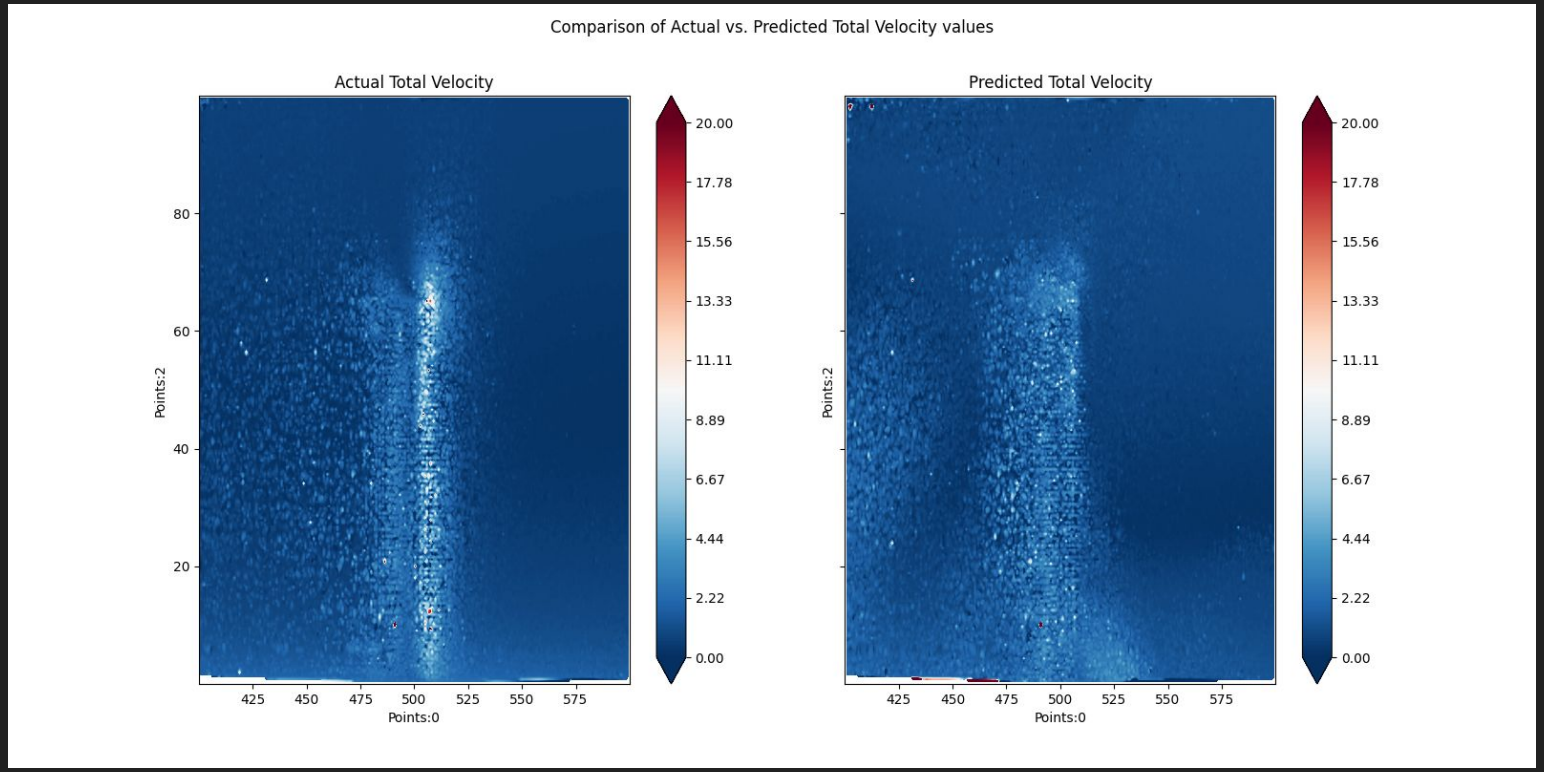
Progress so far - Data Loss Only (Adam Optimizer) - Predicting Results - Metrics

Variable	MSE	RMSE	MAE	R2
Pressure	1.5220883	1.2337295	0.53262806	-0.5220843857
Velocity:0	0.36454695	0.6037772	0.4447443	0.6354540529
Velocity:1	1.0641118	1.0315579	0.54127514	-0.06410897082
Velocity:2	2.498988	1.5808188	0.7100876	-1.498980889

Progress so far - Data Loss Only (Adam Optimizer) - Testing Results - X-Z Pressure Plot



Progress so far - Data Loss Only (Adam Optimizer) - Testing Results - X-Z Total Velocity Plot



Progress so far - Data Loss + Cont Loss (Adam Optimizer)

- Running on laptop with GPU

```
CPU Total Memory: 31.20 GB
CPU Available Memory: 19.24 GB
CPU with optimal batch size: 169
Now using device: cuda:0 with optimal batch size: 139
Estimated Memory Requirement for the Batch Size: 15.75 GB
Estimated Memory Requirement for the Full Size: 191502.83 GB
using batches with forced batch size: 16899
Epoch [100/infinity], Loss: 0.0711
Epoch [100/infinity], Loss: 0.0659
Epoch [100/infinity], Loss: 0.0786
Epoch [100/infinity], Loss: 0.0670
```

```
Epoch [13200/infinity], Loss: 0.0070
Epoch [13200/infinity], Loss: 0.0075
Epoch [13200/infinity], Loss: 0.0076
Epoch [13200/infinity], Loss: 0.0083
Epoch [13200/infinity], Loss: 0.0071
Epoch [13200/infinity], Loss: 0.0079
Epoch [13200/infinity], Loss: 0.0074
Epoch [13200/infinity], Loss: 0.0081
Epoch [13200/infinity], Loss: 0.0073
Epoch [13200/infinity], Loss: 0.0139
```

Progress so far - Data Loss + Cont Loss + RANS loss (Adam Optimizer)

- Running on workstation with GPU

```
2 GPUs available:
GPU 0: NVIDIA GeForce RTX 3090
GPU 1: NVIDIA GeForce RTX 3090
Using device: cuda:1, with 24.348 GB free memory
Skipping Angle - 90 degrees
GPU Total Memory: 24.00 GB
GPU Available Memory: 24.00 GB
GPU with optimal batch size: 211
CPU Total Memory: 255.84 GB
CPU Available Memory: 131.50 GB
CPU with optimal batch size: 1156
Now using device: cuda:0 with optimal batch size: 211
Estimated Memory Requirement for the Batch Size: 23.91 GB
Estimated Memory Requirement for the Full Size: 191502.83 GB
using batches with forced batch size: 16899
Epoch [100/infinity], Loss: 0.1581
Epoch [100/infinity], Loss: 0.1727
Epoch [100/infinity], Loss: 0.1687
Epoch [100/infinity], Loss: 0.1764
Epoch [100/infinity], Loss: 0.1484
Epoch [100/infinity], Loss: 0.1789
Epoch [100/infinity], Loss: 0.1722
Epoch [100/infinity], Loss: 0.1622
Epoch [100/infinity], Loss: 0.1677
Epoch [100/infinity], Loss: 0.1636
Epoch [100/infinity], Loss: 0.1565
Epoch [100/infinity], Loss: 0.1572
Epoch [100/infinity], Loss: 0.1671
Epoch [100/infinity], Loss: 0.1576
Epoch [100/infinity], Loss: 0.1605
Epoch [100/infinity], Loss: 0.1604
Epoch [100/infinity], Loss: 0.1583
Epoch [100/infinity], Loss: 0.1459
Epoch [100/infinity], Loss: 0.1518
Epoch [100/infinity], Loss: 0.1661
Epoch [100/infinity], Loss: 0.1582
```

```
Epoch [3600/infinity], Loss: 0.0069
Epoch [3600/infinity], Loss: 0.0060
Epoch [3600/infinity], Loss: 0.0066
Epoch [3600/infinity], Loss: 0.0068
Epoch [3600/infinity], Loss: 0.0064
Epoch [3600/infinity], Loss: 0.0065
Epoch [3600/infinity], Loss: 0.0068
Epoch [3600/infinity], Loss: 0.0065
Epoch [3600/infinity], Loss: 0.0073
Epoch [3600/infinity], Loss: 0.0068
Epoch [3600/infinity], Loss: 0.0067
Epoch [3600/infinity], Loss: 0.0071
Epoch [3600/infinity], Loss: 0.0072
Epoch [3600/infinity], Loss: 0.0064
Epoch [3600/infinity], Loss: 0.0073
Epoch [3600/infinity], Loss: 0.0067
Epoch [3600/infinity], Loss: 0.0067
Epoch [3600/infinity], Loss: 0.0071
Epoch [3600/infinity], Loss: 0.0065
Epoch [3600/infinity], Loss: 0.0074
Epoch [3600/infinity], Loss: 0.0067
Epoch [3600/infinity], Loss: 0.0072
Epoch [3600/infinity], Loss: 0.0068
Epoch [3600/infinity], Loss: 0.0068
Epoch [3600/infinity], Loss: 0.0071
Epoch [3600/infinity], Loss: 0.0067
Epoch [3600/infinity], Loss: 0.0075
Epoch [3600/infinity], Loss: 0.0068
Epoch [3600/infinity], Loss: 0.0065
Epoch [3600/infinity], Loss: 0.0070
Epoch [3600/infinity], Loss: 0.0072
Epoch [3600/infinity], Loss: 0.0065
Epoch [3600/infinity], Loss: 0.0073
Epoch [3600/infinity], Loss: 0.0066
Epoch [3600/infinity], Loss: 0.0079
```